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# Cost-Benefit Analysis of Farmer Training in Ghanaian Cocoa Farming

Michael Norton

*University of Arkansas, Fayetteville*

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Cost-Benefit Analysis of Farmer Training in Ghanaian Cocoa Farming

An Undergraduate Honors Thesis

in the

Department of Agricultural Economics and Agribusiness

Submitted in partial fulfillment of the requirements for the

University of Arkansas

Dale Bumpers College of Agricultural, Food and Life Sciences

Honors Program

by

Mike Norton

April 2013

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Dr. Lanier Nalley, Chair

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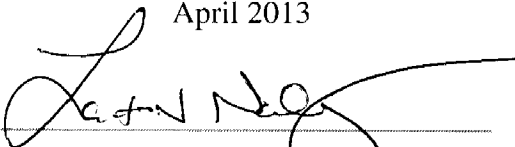
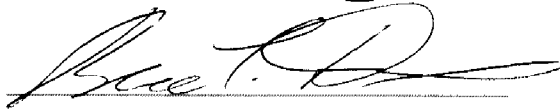
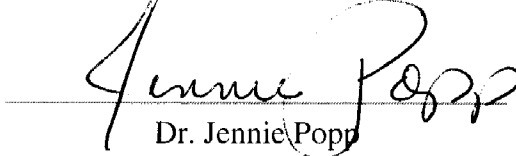
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## **1. Introduction**

While billions of dollars flow into low-income countries each year to help alleviate poverty, assessing the effectiveness of these dollars is a challenging task. Because of poor infrastructure and communication networks, as well as a lack of transparency in the sources of information, collecting and evaluating data to measure the impact of development projects in low-income countries is difficult. Meanwhile, the global economic recession, coupled with budget cuts across high-income countries, has resulted in fewer unrestricted funding sources for large-scale development projects (CGIAR, 2012). Donors for poverty alleviation projects are increasingly asking for higher resolution impact and evaluation data for their projects. Thus, to adequately measure the impacts of a poverty alleviation project, monitoring and evaluation teams must be inherently results-oriented with the data to support claims (UNDP, 2009).

The literature is rich in studies that measure the benefits of rural development programs. However, many of these studies lack a temporal dimension because they measure costs and benefits for only capital investments and for only a single, static year, while not accounting for skill enhancement dividends paid over a longer horizon. Farmer training programs can involve human capital acquisition. The benefits can persist long after the training program has officially ended. As a result, farmers develop skill sets that can extend well past the single year (or few years) of the training program. By accounting only for net producer benefits during the life of the development program, the cost-benefit analyses (CBA) may not truly capture the full net benefits of a given program. Therefore, a more comprehensive approach of cost-benefit analysis must be utilized when evaluating projects that invest in human capital. Such analyses should give future donors a more complete portrait of potential investment returns. With that in mind, this study undertakes a cost-benefit analysis of a 2009-2014 Bill and Melinda Gates/World Cocoa

Foundation (WCF) training program for Ghanaian cocoa producers. The goal of the training program is to teach cocoa producers in five West African countries agricultural practices such as proper pruning, drying techniques, and harvesting methods to improve their agricultural production and thus their livelihoods. To more comprehensively measure the costs and benefits of such a program, the values should be calculated over an extended horizon, rather than simply accruing the five-year benefits that correspond with the life of the program itself. Net present value (NPV) is a standard measure of intertemporal, net benefits resulting from an investment. By calculating the NPV change due to the human capital obtained, the complete net benefits of the grant and training program(s) can be measured. This type of intertemporal accounting of net benefits makes the full return to grant programs more clear.

In Ghana, where approximately 52% of the population lives on USD \$2 a day or less, 27% live on \$1.25 or less per day, and 19% of rural households produce cocoa, measuring the full impact of agricultural development programs can generate information needed to more efficiently invest scarce resources (World Bank, 2013; Breisinger et al., 2008).

With the introduction of structural adjustment programs (SAPs) in the 1980s, there was an overall decline in agricultural research, farm extension, and rural banking services that play an integral role in tree crop production enterprises like cocoa in Ghana. To fill this void for cocoa, in 2009 WCF undertook the Cocoa Livelihoods Program (CLP) in conjunction with the Bill and Melinda Gates Foundation and sixteen member companies involved in the chocolate, cocoa, and coffee industries. The goal of CLP is to increase cocoa production and thereby strengthen the economies of cocoa-growing communities. CLP operates production and management training and credit programs to help accomplish its goals. To estimate the benefits of this program, this study uses primary data collected from the 2009-2010 growing season in Ghana to estimate the

impact that the training program has had on producer output and thus returns. The primary data allowed a comparison between yields and costs for farmers who attended the farmer training and for those that did not. From this comparison, the study implements an NPV model using the 25-year parabola shaped lifecycle yield curve (average productive life) of a cocoa tree in Ghana based on research conducted by the International Institute of Tropical Agriculture (IITA) and Mahrizal et al. (2013). The NPV model estimates the value of CLP training over two production cycles, or a 50-year period, assuming that one hectare is going to be planted after a producer completes CLP training. The hypothesis of the study is that CLP farmers will experience an increase in livelihood quality due to increased cocoa yields associated with farmer training.

## **2. Literature Review**

### *2.1 Poverty in Ghana*

Real Ghanaian gross domestic product (GDP) has increased 4% annually since 1986, helping real per real capita income grow by over 30% for the period 1986 to 2004 (Brooks et al., 2007). Between 2007 and 2011, annual GDP growth rate was 8.3% (World Bank, 2013). In 2011, the country's per capita income reached \$1,410 and it attained lower middle-income status according to World Bank classifications. However, this increase is more than likely linked to oil discovery and high gold prices, which can lead to unevenly distributed growth and development (World Bank, 2013).

As illustrated in Table 1, food poverty (the estimated food expenditure per person per year needed to meet minimum nutritional requirements hence “extreme poverty”) as well as overall poverty (measured at an income of \$1.25 per day) has consistently fallen since 1991 (Breisinger et al., 2008; Ghana Statistical Service, 2000; National Development Planning Commission, 2012). Ironically, farm households experienced a higher incidence of food poverty

ranging from 52% to 45% between 1991 and 1998, respectively. In the past thirty years, the percentage of the poor that produce food crops has increased while the share attributed to export crop producers has decreased (National Development Planning Commission, 2012). Thus, in Ghana like many low-income countries those who are the poorest and the most food insecure are smallholder agricultural producers. Considering the divergent results between food crop producers and export crop producers in recent decades, cocoa production exists as a potential pathway to economic development for Ghana's rural poor.

Table 1: Poverty in Ghana.

Category	1991-1991	1998-1999	2005-2006
% of Population Food Poverty	36.5	27.0	18.2
% of Population Poverty	51.7	29.5	28.5
% of Poor Food Crop Producers	57.3	58.1	68.5
% of Poor Export Crop Producers	7.8	6.9	6.2

In Ghana, 60.1% of cocoa farmers were below the poverty line in 1991. By 2007, that figure had dropped to 23.9% (Coulombe and Wodon, 2007). Economic growth has also positively affected poor cocoa farmers more than the poor in other sectors of the economy (Breisinger et al., 2008). Much of this can be attributed to improved cocoa varieties. However, these hybrids may cause greater soil damage than conventional varieties if used without fertilizers, thus necessitating the need for production skill development and credit access. In recent years, poverty has actually increased for the more arid, northern regions of Ghana less involved in cocoa production, largely due to a decrease in agricultural and non-farm income (Brooks et al., 2007). Many cocoa-growing regions have poverty rates below the national

average (Breisinger et al., 2008). Nevertheless, Afari-Sefa et al. (2010) estimates that the average annual per capita income among cocoa-producing households is \$153.30, indicating there is still ample room for income enhancement.

## *2.2 Impact of Structural Adjustment Programs on Cocoa*

In the early 1980s, the World Bank and International Monetary Fund began instituting structural adjustment programs (SAPs) that led to a reduction of government initiatives to “[open] up economic activities to the free play of market forces,” which led to a decline in agricultural research, farm extension, and rural banking that play an integral role in tree crop production enterprises like cocoa (Nyemeck et al., 2007; Wilcox and Abbot, 2006). This decline in public funding was coupled with a decline in official development assistance, decreasing by almost half between 1980 and 2005 when adjusted for inflation and resulting in fewer funds to implement agricultural development projects in West Africa and across the globe (Cabral, 2007).

Before the SAPs, many West African cocoa producers received free or subsidized fungicides, herbicides, fertilizers, and technical training, which in their absence have led to declining yields and increasing volatility for cocoa producers, particularly for the rural poor who live on marginalized land susceptible to weather and yield variability (Nyemeck et al., 2007). This can lead to lower output, sale of productive assets, reduced consumption, and/or reduced investments in education if problems persist (Hill and Torero, 2009). Current agricultural loans to Ghanaian cocoa farmers come in the form of input packages, primarily through farmer associations or non-governmental organizations (NGOs). A larger banking (lending) system that provides credited inputs to more producers has the potential to both: 1) ease the capital constraints currently imposed on farmers by smoothing seasonal cash flow deficits that are



currently solved by discretionary use of limited resources by households, and 2) improve the ability of cocoa producers to obtain and utilize agricultural inputs (Nyemeck et al., 2007).

### *2.3 Cocoa Production in Ghana*

Agriculture represented 32.3% of GDP in 2010, the second highest export behind gold (World Bank, 2012; Mhango, 2010). In 2005, cocoa production was 18.9% of agricultural GDP and 7.3% of overall Ghanaian GDP (Breisinger et al., 2008). By 2015, cocoa is projected to account for 16.5% of agricultural GDP and 6.5% of overall GDP (Breisinger et al., 2008). During the 2010 growing season, Cameroon, Côte d'Ivoire, Ghana, and Nigeria together accounted for 71.4% of world cocoa production (WCF, 2012). Ghana alone represented 20.5% of global cocoa production in 2010 and was (and remains) the second largest exporter behind Cote d'Ivoire (WCF, 2012). Yet, it should be noted that the number of beans harvested per hectare in Ghana is “among the lowest in the world” (Caria et al., 2009).

The Ghana Cocoa Board (COCOBOD) is the sole exporter of Ghanaian cocoa, guaranteeing farmers a minimum price at 70% of the net free on board (FOB) price (Kolavalli et al., 2012). In the 1998 growing season, the actual Ghanaian farm gate price as a percent of increased to nearly 80% (Kolavalli and Vigneri, 2011). For the 2012 growing season, farmers received 76.04% of the FOB price (Government of Ghana, 2012). Still, net FOB prices in Ghana are lower than its more liberalized neighbors Côte d'Ivoire, Togo, Nigeria, and Cameroon (Mohammed et al., 2012; Kolavalli and Vigneri, 2011). Ghanaian cocoa production is partially liberalized, allowing private licensed buying companies (LBCs) to buy, sell, and transport cocoa. However, COCOBOD sets a minimum price and is currently the only exporter. COCOBOD's primary LBC competitors are Kuapa Kokoo, Olam, Armajaro, and Global Haulage (Kolavalli and Vigneri, 2011). LBCs are allowed to export, though none have reached the minimum

quantity of beans to be eligible to export (Kolavalli and Vigneri, 2011). Given COCOBOD's predetermined minimum pricing system, the LBCs' sole option for competing with each other on price is through price bonuses for higher quality cocoa (often tied to a certification program). They can also differentiate themselves through gifts such as exercise books, cakes of soap, salt, subsidized inputs, or credit programs largely implemented through farmer-based organizations (FBOs) like Cocoa Abrabopa (Laven, 2007; Caria et al., 2009; Kolavalli and Vigneri, 2011). Cocoa Abrabopa is a not-for-profit partner of the Dutch/Ghanaian agricultural company Wienco and provides credit for farmers to buy Wienco agricultural inputs before the season begins. LBCs rarely pay above the minimum COCOBOD price due to the cost associated with doing so (Seini, 2002; Kolavalli et al., 2012).

#### *2.4 The World Cocoa Foundation and the Cocoa Livelihoods Program*

The World Cocoa Foundation is a Washington, D.C.-based NGO with programs in Central and Latin America, Southeast Asia, and West Africa. The Foundation promotes sustainable cocoa production, both economically and environmentally, while improving the livelihoods of cocoa growers and cocoa-growing communities. The Cocoa Livelihoods Program (CLP) is supported by \$17 million from sixteen member companies involved in the chocolate, cocoa, and coffee industries such as Hershey's Nestle, Kraft, Mars, Starbucks, and Godiva. Additionally, it has received financial support of \$23 million from the Bill and Melinda Gates Foundation, as well as technical support from the German government's Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Canada-based NGO Société de Coopération pour le Développement International (SOCODEVI), U.S.-based NGO TechnoServe, IITA's Nigeria-based Sustainable Tree Crops Program (STCP), and the governments of Ghana, Liberia, Cameroon, Nigeria, and Côte d'Ivoire.

In Ghana, CLP operates three cocoa farming training programs and one credit operation. The cocoa training programs relate to three areas (in this order): production management, business management, and input management. The credit operation provides input loans via TechnoServe. The three training programs are respectively labeled farmer field school (FFS), farmer business school (FBS) and input promoter (IP). When the funding expires in 2013, CLP will have granted credit access to and trained 44,200 Ghanaian cocoa farmers between 2009 and 2013. The number of farmers trained per country was proportional to the share of cocoa production within the five West African countries and multiplied by the 200,000 total farmers trained in West Africa. Farmers wishing to participate in CLP are asked to form groups of 15-30 individuals. Further selection criteria are: age not greater than 60 years old, farms at least 2.5 acres planted with hybrid cocoa with a maximum age of ten years, and has access to at least one hectare of land to establish a new cocoa farm planted with hybrid cocoa.

COCOBOD teaches the FFS. The immediate impact of FFS should be improved agronomic production skills to better manage the agronomic health of cocoa trees through fertilizer use and prevention of disease and pests. Specifically, farmer field schools provide training in safety practices, fermentation methods, replanting, farming techniques, estimating farm size, pruning, and managing persistent pests like mealy bugs and aphids. FFS also educates farmers on broader social goals such as HIV awareness and children's education. FFS in Ghana is not a traditional FFS. Curriculum is customized based on preliminary questions to ascertain specific farmer deficiencies.

The second phase of CLP is the FBS, which is taught by GIZ. FBS gives farmers the financial tools to balance a budget, work within FBOs, and act as a farmer entrepreneur. The program is primarily concerned with shifting farmer perceptions from farming as a lifestyle to

farming as a business. The curriculum accomplishes this by reviewing the farming measurements (hectare, kilometer, kilogram, liters), observing caloric values to ensure families receive the required nutrition, stressing the importance of a balanced budget, practicing balancing a budget, and demonstrating the benefits of crop diversification. The course also evaluates financial services, methods to increase cocoa quality, FBO membership, and the advantages of replanting cocoa. The central message of FBS is that farming is an entrepreneurial activity.

TechnoServe, which also facilitates the credit program, teaches the final phase of CLP: input promoter. The course involves using inputs and, upon graduation, farmers are able to receive input loan packages via TechnoServe at a 10% down payment, underwritten by Opportunity International. The curriculum specifically assesses ways in which the farmer can expand production through the use of inputs, such as chemical fertilizer, fungicides, and insecticides. Safety precautions when spraying and mixing chemicals are also included in the program. By the final phase of CLP, farmers should know proper crop management techniques, how to budget and coordinate financial resources, and finally how to safely use chemical inputs.

### *2.5 Previous Cost-Benefit Analyses in Development Programs*

Several past cost-benefit analyses of tropical agriculture are used for comparisons of the results of this study. Wienco's FBO Cocoa Abrabopa in conjunction with the Center for the Study of African Economies (CSAE) conducted a study in 2007 to assess the impact of Cocoa Abrabopa's field representative training and farmer loan program in Ghana (Caria et al., 2009). The program differs from CLP in that farmers are not trained. Instead, Cocoa Abrabopa representatives are trained in production practices like FFS and then go into the field to advise the 11,000 member-farmers. These representatives do not directly sell inputs to farmers, but do provide group-based input loans. Cocoa Abrabopa also gathered information from non-

participating farmers to directly compare participating farmers to non-participating farmers. There were 239 farmers in the sample. The methods used to collect the data are not clear. The notable results of the study were a recognizable 40% average increase in yield for the 2007/2008 growing season and an economic return of over 250% (benefit cost ratio (BCR) of 2.5) after accounting for the cost of the input loan excluding operational costs of program (Caria et al., 2009). The study found increased labor use was not substantial enough to alter the cost-benefit ratio. More importantly, the study found incorrect use of fertilizer and other inputs was still a common problem, signifying that credit accessibility is only part of the solution, while training on proper input usage can be as pivotal as the availability of inputs themselves.

Afari-Sefa et al. (2010) conducted another CBA for cocoa production, estimating the costs, benefits, and NPV of Rainforest Alliance-certified cocoa production in Ghana. Certification requires farmers to adopt medium shade density (70 trees per hectare with a minimum of 12 compatible indigenous species) to “increase biodiversity and other environmental services” (Afari-Sefa et al., 2010, 5). The other major burden of certification is purchasing protective equipment for pesticide mixing and application. The core benefit was the 144 Ghana cedi (GH¢) per ton price premium for certified cocoa, a value assumed by Afari-Sefa et al. The NPV of certification calculated over 15 years for high input, medium shade Amazon-certified cocoa was positive for an 85% FOB price share with a 1.075 BCR and again positive for a hypothetical 25% training yield increase with a 1.087 BCR (Afari-Sefa et al., 2010). These estimates included a training yield gain and accounted for human development capital that remained unaddressed in prior studies. The study notes its limitations in not incorporating all certification costs and not accounting for future price or cost volatility.

Another cost-benefit analysis, Alam et al. (2009) examined a participatory agroforestry program in Bangladesh, intended to combat unregulated, unsustainable deforestation. The study observed financial viability, environmental sustainability, and management issues of a forestry program created to manage farmers' needs within forest ecosystems. Farmers were allotted one hectare per participating farmer. Costs were calculated for land preparation, maintenance, pesticides, fertilizer, seeds, and labor. Benefits included income attained from pineapple, zinger, and mustard production, among others. The study found a BCR of 4.12 and an NPV of \$17,710 over a 10-year rotation. Alam et al. (2009) illustrated the financial viability of sustainable agroforestry programs.

A CBA was also conducted for an agricultural development project in Senegal. Weiler and Tyner (1981) analyzed the Nianga area irrigation project that included: 35 mixed agriculture farms, a seed farm, an experiment station, a training program, housing for government workers, and a sheep feed lot, covering 632 hectares of irrigable land in total. They calculated the BCR to be between 1.365 and 0.851 depending on the discount rate (5% or 15%). The authors cited operating expenses and preliminary costs as the primary factors affecting the BCR.

Mahrizal et al. (2013) utilized cocoa production data collected by STCP and IITA to estimate an optimal replacement rate (ORR) and initial replacement year (IRY) to maximize a 50-year NPV for a hectare of cocoa production in Ghana by employing a phased replanting approach. The authors found that the annual ORR is 5% to 7% across the three different production systems studied: Low Input, Landrace Cocoa (LILC), High Input, No Shade Amazon Cocoa (HINSC), and High Input, Medium Shade Cocoa (HIMSC). They also estimated that the optimal IRY ranges from year five to year nine as a function of cocoa prices, fertilizer prices, labor prices, and percentage yield loss due to disease outbreaks. From the ORR and IRY values,

the authors estimated economic gains that exceed currently practiced replacement approaches by 5.57% to 14.67% across production systems with reduced, annual income volatility. They concluded their method could be used to increase cocoa yields and stabilize income over time, thus facilitating substantial quality of life improvements for many subsistence cocoa farmers in Ghana and around the world.

### **3. Methodology**

#### *3.1 Data*

A survey was conducted in ten WCF CLP communities in July 2011 in the cocoa growing regions of Ghana, which were selected using cluster sampling of three production regions<sup>1</sup>. All CLP communities were grouped according to training received (FFS, FFS/FBS, or FFS/FBS/Input) and selections for the survey were randomly made within the respective groups. Once the ten communities were chosen, purposive sampling was employed to select both male and female cocoa producers<sup>2</sup>. The targeted and attained sample size was 183 farmers (126 men and 57 women). The sample size was calculated to have approximately 18 farmers from each of the ten communities. The sampling frame was obtained from Fortson et al. (2011), a study conducted by Mathematica Policy Research Inc. during the 2009/2010 cocoa growing season on behalf of WCF to measure yields of farmers “most likely to benefit from the program” (Fortson et al., 2011). Thus, the sample identified by Mathematica should be representative of cocoa producers in Ghana who are likely to participate in the training program. It should be noted that each community had received some form of CLP training by the time this study was

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<sup>1</sup> The 10 villages (district in parentheses) were: Adankwame (Atwima Nwabiagya), Afere (Juaboso), Datano (Juaboso), Bonzain (Juaboso), Ntertreso (Sefwi Wiawso), Domeabra (Sefwi Wiawso), Akim-Aprade (Birim South), Oforikrom (Birim South), Anyinam-Kotoku (Birim South), and Djanikrom (Birim South). Fig. 1 illustrates geographic positions.

<sup>2</sup> Women were intentionally overrepresented in the sample to provide reporting data to donor agencies on female farmers' practices and yields.

implemented. Of the 549 training units (one farmer graduating from any one of the three programs) experienced by the 183 farmers in our survey, 256 (46.6%) occurred after the 2010-2011 harvest. Because the yields from this group's farmers were not affected by the training at the point of data collection in summer 2011, they are the controls for measuring the impact of the training programs.

The CLP survey was implemented to collect qualitative and quantitative information about the producers and their production behavior. Data collected included: 1) name, 2) gender, 3) age, 4) district, 5) village, 6) total area planted in hectares, 7) FBO membership, 8) total farm yield (measured in 64kg bags), 9) WCF training received including the year, 10) source of planting material for their farm both pre- and post-training, and 11) implementation of different farm management practices. Farm size was based on farmer estimations because many farms were non-contiguous and GPS mapping was not common. Since FFS incorporates a module on the proper measurement of farm size, producer-reported farm size should be a relatively accurate approximation. For observations where multiple family members co-managed a farm, only one manager was interviewed. For farms with both a farm manager and a farm owner in which only one received training, the two were interviewed together. If language barriers existed between farmers and interviewers, a translator was utilized. The questionnaire was administered with the assistance of local technical partners under supervision of the WCF Monitor and Evaluation team.

### *3.2 Methods and Data*

To estimate the yield enhancement attributable to the various levels of CLP farmer training, a semi-log linear regression model was specified and estimated by ordinary least squares. The dependent variable was yield measured in kilograms of cocoa beans per hectare. The independent variables were FFS training, FBS training, input promoter (IP) training, gender,



farm size, FBO membership, fertilizer use, fungicide use, insecticide use, herbicide use, improved cocoa varieties, seed source, and location.

The model can be written as:

$$\log Y_i = \alpha + \beta_{1i}FFS + \beta_{2i}FBS + \beta_{3i}IP + \beta_{4i}Gender + \beta_{5i}FarmSize + \beta_{6i}FBO + \beta_{7i}Fert + \beta_{8i}Fung + \beta_{9i}Insect + \beta_{10i}Herb + \beta_{11i}ImprVar + \varphi_{1i}SeedSource + \varphi_{2i}Location + e. \quad (1)$$

The dependent variable  $Y_i$  represents yield of dried cocoa beans for individual farm  $i$  in kilograms per hectare. A natural log was used because a semi-log regression model calculates the percentage yield increase associated with training (rather than in kilograms per hectare), resulting in a more accurate NPV model.  $FFS$ ,  $FBS$ , and  $IP$  are binary variables taking on a value of one if the  $i^{\text{th}}$  participant had completed the CLP farmer field school (FFS), farmer business school (FBS) and input promoter (IP), respectively. The control producer group consists of those farmers who had no CLP training.  $Gender$  is a binary variable taking on the value of one if the  $i^{\text{th}}$  participant is male.  $FarmSize$  is the natural log of participant  $i$ 's cocoa farm size in hectares.  $Fert$ ,  $Fung$ ,  $Insect$ ,  $Herb$ ,  $ImprVar$ , and  $FBO$  are binary variables taking on the value of one if the  $i^{\text{th}}$  participant used inorganic fertilizer, fungicide, insecticide, herbicide, improved cocoa varieties, or was a member of an FBO, respectively.<sup>3</sup> The coefficient vector  $\varphi_1$  contains coefficients for the origin of seed stock binary variables (own farm and friend's farm, with government certified seed acting as the control origin) and  $\varphi_2$  contains coefficient binary variables indicating the location of the farm (the districts Atwima Nwabiagya, Juaboso, and Sefwi Wiawso, with Birim South acting as the control district). Because of the cross sectional nature of the sample, the standard errors of the estimated coefficients are heteroscedasticity consistent standard errors as

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<sup>3</sup> Ideally, the amounts of fertilizer, fungicide, herbicide, pesticide, and insecticide would have been collected. However, given the non-contiguous nature of most producers' farms, the two growing seasons for cocoa, and that fertilizer may not be applied every year, these data sets were not obtained.

given in White (1980). As a result, the ratio of the estimated coefficients to their estimated standard errors is distributed asymptotically as standard normal under the null hypothesis.

### *3.3 Net Present Value*

Given the estimated yield increases from the various CLP training programs from equation (1), a net present value (NPV) of total benefits can be calculated using the methods implemented in Mahrizal et al. (2013). Like Mahrizal et al., this study solves for the optimal IRY and ORR. Given this solution, the net future value (NFV) in each year is computed as a function of returns, the replacement rate, year of replacement, and inflation rate. Then, the NPV is computed as the sum of the annual, discounted NFV in each year. This study considers the importance of both the inflation rate (because it is often high in low-income countries), since it increases the nominal price level over time and strongly affects the future value of money, and the importance of the discount rate, since it determines the present value of net returns from future periods.

A baseline NPV was computed using the results of the Mahrizal et al. (2013) study that used the same production data set as this study. A two-dimensional matrix is constructed in Excel with varying annual replacement rates (the ORR) along the columns and an initial year for beginning replacement along the rows (the IRY). Each element in this matrix is the NPV for a given replacement rate and the associated initial replacement year. The ORR ranges from 4% to 10% and the IRY ranges from year 5 to year 20.<sup>4</sup> The combination of percentage of replacement rates and IRY which gives the highest NPV is the optimal solution.<sup>5</sup>

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<sup>4</sup> “Replacing cocoa trees by less than 4% or over 10% indicates that the completion of replacement of an entire farm for one production cycle would take 33.3 to 100 years or 9 years or less, respectively. Setting the IRY at less than 5 years of age or over 20 years of age is not necessary since the cocoa trees bear fruit starting at age three and decreasing yields begin after year 20” (Mahrizal et al., 2013, 17).

<sup>5</sup> “For all scenarios solved, all optimal solutions were in the interior of the matrix, i.e., no corner solutions. This justifies having  $4\% \leq \text{ORR} \leq 10\%$  and  $5 \leq \text{IRY} \leq 20$  in the search procedure for the ORR and optimal IRY” (Mahrizal et al., 2013, 17).

From the optimal ORR and IRY that maximizes NPV solved for in the Mahrizal et al. (2013) study, a baseline scenario can be computed to estimate the NPV for participants who are maximizing NPV without the benefit of CLP training. A baseline was established using ORR and IRY to highlight the maximum potential profit that could be achieved for producers given current production practices without CLP training. Given the biological life cycle of a cocoa tree which has a production peak with a decreasing yield over time (Fig. 2), an alternative baseline, not addressed in this study, would be to simply not replace trees, letting the entire orchard reach zero yield, and subsequently replacing all of the trees at once. Following Mahrizal et al. (2013) who concluded that cocoa yield decreases at an increasing rate over time, it is clear that some form of replacement is needed to both stabilize and optimize cocoa producers' annual returns over time. Thus, the baseline is established using ORR and IRY implying that producers are acting in a profit-maximizing manner before the CLP training is implemented.

It is assumed that the yield benefits estimated in Equation 1 as attributable to the various training programs (*FBS, FFS, and Input Promoter*) could be a constant percentage gain associated with each level of training, above those cocoa producers who did not participate in the various CLP trainings (baseline scenario) over the life of the cocoa tree<sup>6</sup>.

The calculations for net future value, and net present value were made as follows.

Net Future Value (NFV) is equal to:

$$NFV_t = Yld_t(1 + X\%) * P_t(1 + r)^t - C_t(1 + r)^t \quad (2)$$

Where:  $NFV_t$  = Net future value in period t.

$Yld_t$  = Yield (kg/ha) of cocoa in period t for a given hectare, and depends upon the age distribution of trees on that hectare.

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<sup>6</sup> The constant gain would increase yields at each stage of growth by that percent. That is, at a 10% yield increase level, 100 kg/ha at year 10 would increase to 110 kg/ha while 200 kg/ha at year 20 would increase to 220 kg/ha.

$(1+X\%)$  yield increase with various CLP training.  $X=0$  represents the baseline yield.

$P_t * (1 + r)^t$  = Cocoa price in period  $t$  compounded by inflation rate  $r$ .

$C_t * (1 + r)^t$  = Cost of cocoa production in period  $t$  compounded by inflation rate  $r$ .

The NPV for the 25-year productive life of the tree is computed as:

$$NPV = \sum_{t=1}^T N F V_t \frac{1}{(1 + r_d)^t} \quad (3)$$

where  $r_d$  is the discount rate and  $t$  runs from year 1 to year 50, or two cocoa production cycles.

The annual average return is calculated by dividing the NPV by 50, giving the annual average present value of profit per hectare per year. The model assumes no salvage value for cocoa trees consistent with Ward and Faris (1968) and Tisdell and De Silva (2008). A baseline NPV (no CLP training or  $X=0$ ) is estimated using a cost, yield, and input price structure as derived from Gockowski et al. (2009) and the optimal ORR and IRY calculated by Mahrizal et al. (2013) of 6% and year 9, respectively.<sup>7</sup>

The baseline production practice chosen for the study was classified as Low Input Landrace Cocoa (LILC) production system described in Mahrizal et al. (2013). The system uses unimproved, local landrace cocoa varieties with pesticides and fungicides over the life cycle, but no inorganic fertilizer. Costs and returns are estimated for 1 hectare of unimproved cocoa planted at 3 x 3 m spacing (1,100 plants per hectare). No nursery costs are incurred as the farm is directly seeded with unimproved LILC cocoa varieties. Typical of most Ghanaian farmers, it is assumed that there is no use of agrochemicals other than those provided by the Government of Ghana's mass spraying program, which is subsidized by COCOBOD. The amount of pesticides and

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<sup>7</sup> Baseline Labor was fixed at GHC 3.5 per day per laborer or USD \$2.37 (2010 dollars) as estimated in Gockowski et al. (2009). Fertilizer, insecticide, and fungicide prices were respectively fixed at GHC 14.7 per 50kg or USD \$9.98, GHC 16.8 per liter or USD \$11.40, GHC 1.8 per sachet or USD \$1.2 (all in 2010 dollars). By setting inflation at 10.26% per year, the prices of labor and inputs would rise at this rate. The baseline exchange rate was held constant at GHC 1.47 per USD, per the 2010 average (Mahrizal et al., 2013).

fungicides used on average for LILC is 0.11 liters of Confidor per year and 31.68 sachets (50 grams) of Ridomil per year, respectively provided by the government. Prices for these inputs were obtained from Afrari-Sefa et al. (2010). The study also assumes that shade levels for LILC system are 70 shade trees per hectare. The LILC production system is chosen as the baseline because it is popular with impoverished producers who cannot obtain financing for inputs, the very target of the CLP program. Thus, the baseline scenario portrays those producers who implement LILC cocoa production using the optimal ORR and IRY to maximize NPV, but who have had no CLP training. Once a producer has finished input training (*IP*), it is assumed that they would have access to inorganic fertilizer and fungicide, thus production costs would need to increase as well. To account for this, all producers who have input training (*IP*) have associated higher costs of production. Cost estimates for High Input Medium Shade Cocoa (HIMSC) were obtained from Afrari-Sefa et al. (2010). The only difference between the cost estimates of LILC and HIMSC is the use of inorganic fertilizer, fungicide, and herbicide. From these new cost estimates, a more accurate profit can be estimated because the large theoretical yield increases associated with *IP* should be associated with higher input costs.

Revenue was calculated by multiplying yield in kilograms per hectare for time period  $t$  by the price of cocoa in time period  $t$  in USD per kilogram. Given the COCOBOD marketing board pricing structure, Ghanaian farmers received 76.04% of the FOB price in 2012 so cocoa price was set at USD \$2,513.72 per metric ton of beans or 76.04% of the ICCO price of USD \$3,305.79 (2011 dollars) per metric ton of beans as observed on May 2, 2011. The COCOBOD retains a portion of the FOB price to reinvest in the cocoa economy in the forms of educational scholarships, input and supply subsidies, and research in an attempt to increase yields and decrease costs. Inflation was estimated at 10.26% based on the annual average inflation in

December 2010 (Bank of Ghana, 2011a). The discount rate was 10.67% using Treasury bill rates for a six-month period (Bank of Ghana, 2011b).

### *3.4 Benefit Cost Ratio*

The difference between the baseline NPV (no training) and the CLP training program estimated NPV in Equation 3 would be the discounted benefits of the training program. Thus, the benefit-cost ratio (BCR) would be equivalent to:

$$BCR = \frac{B_x}{C_{0x}} \quad (4)$$

Where  $B_x$  is the discounted benefits of the CLP training program minus the baseline NPV (no training) in USD per hectare and  $C_{0x}$  is the total cost of the training program per person assuming all costs of training are incurred at time 0. Training costs for the CLP program in Ghana were assumed to all occur in year one of the program. The World Cocoa Foundation estimated costs of the farmer field school (FFS) and farmer business school (FBS) to be USD \$36 and USD \$16, respectively, per participant (2010 dollars). WCF also stated that the input promoter training costs USD \$200 (2010 dollars) per producer to implement. Therefore, the total cost of farmer training is USD \$252.

## **4. Results**

### *4.1 Regression*

Table 2 presents a summary of average variable values, divided by district. The average farm size was 3.2 hectares. Juaboso had the largest average farm size at 4.2 hectares, while Birim South had the smallest at 2.3 hectares. The average yield in kilograms per hectare was 562.6. Sefwi Wiawso had the largest yield with 854.9 kilograms per hectare. Atwima Nwabiagya had the smallest at 213.2 kilograms per hectare. Of the sample, 68.9% were male, 76.5% completed

FFS, 72.1% completed FBS, and 11.5% completed IP. The 11.5% that had completed IP were concentrated in Juaboso and Sefwi Wiawso.

Table 3 presents the results of the regression. The R-squared was 0.36, meaning the model can describe 36% of the variability. Seven of the 16 variables (not counting the constant term) were statistically significant at the 10% level or better. Gender was statistically significant at the 5% level, demonstrating that being male was associated with a 33% increase in yield<sup>8</sup>, all other variables held constant. This may be correlated with the social status of males versus females in West African societies, particularly with banking access or land ownership, as well as the physical labor demands of cocoa farming. Farm size (measured in natural logs) with an estimated coefficient of -0.04 was significant at the 1% level, meaning that for every 1% increase in farm size, production decreased 0.04%. Considering a farmer's labor resources are typically finite, it would be expected that yield in kilograms per hectare would decrease as hectares increase, since the farmers have fewer resources to provide to each tree. Fertilizer and insecticide use were also statistically significant at the 5% and 10% levels with a 54% increase and 34% in yield, respectively. Yield would be expected to increase with use of these inputs, given that fertilizer improves soil quality and pests like mirids can cause a 30-40% yield loss.

The training coefficient estimates provide the most interesting feature of the regression. Attending FFS (farmer field school) was associated with a 77.2% increase in yield, but it was not statistically significant. *FBS* (farmer business school) had a positive coefficient (2.2% increase in yield with training); however, it was also not statistically significant. The only training that was

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<sup>8</sup> Note that the estimated coefficient of Gender is 0.29. Because the dependent variable (yield) is in natural logs, the coefficient of any given variable is the continuous change rate for a one-unit change in the associated independent variable for a dependent variable. But for a binary variable like Gender, the full impact of going from zero to one in a discrete jump requires exponentiating the coefficient, subtracting one, and multiplying this difference by 100 to get the full percentage change when a binary variable goes from zero to one.

statistically significant was *IP* (input promoter), which was significant at the 1% level and associated with a 75.24% increase in yield.

There are several reasons why *FFS* and *FBS* are not statistically significant. *FFS* is the introductory program to *CLP* and provides foundational production practices that may not be implemented without additional inputs and sound financial management. Among other concepts, *FFS* covers safety practices, fermentation methods, and farm size estimation that could lead to a higher quality of life and a higher quality of cocoa bean, but may not necessarily increase yield per hectare.

Additionally, *FBS* stresses the importance of a balanced budget, demonstrates the benefits of crop diversification, analyzes the caloric intake of farm families, and reviews common farming measurements such as kilograms and hectares. A balanced budget and crop diversification will facilitate a healthier financial position, but like safety practices or fermentation methods with *FFS*, those practices may not manifest themselves in yield enhancements. It is assumed that ensuring families receive enough calories to subsist and have access to financial services would increase overall quality of life; however, this regression model does not seek to explain quality of life factors, so it is not surprising that *FBS* and *FFS* are not statistically significant.

Initially, it was expected that *IP* would be statistically significant, considering it is the capstone course of three training courses. It teaches farmers how to expand production through the use of chemical fertilizer, fungicides, and insecticides. Upon graduation farmers are able to access the human capital and knowledge base that they obtained from all three programs and, perhaps more importantly, they qualify for microcredit loans via TechnoServe (>95% of graduates take out loans). The financial skills they attain during *FBS* could be fully realized if



they are able to access credit, and the use of inputs could fully utilize the production skills obtained in FFS. For this reason, the yield increase associated with IP is used with the NPV model to approximate the overall value of training in comparison to the baseline scenario.

#### *4.2 Net Present Value*

Table 4 presents the annual NPV estimates for the (1) baseline analysis from Mahrizal et al. (2013), (2) for the 75.24% yield increase associated with the statistically significant input promoter (*IP*) training course found on Table 3, and (3) a sensitivity analysis to provide reference and break-even points. Given that input promoter (*IP*) is the capstone training course, the percentage yield increase associated with its completion can be recognized as the total yield increase for completing the CLP farmer training program.

The baseline NPV (Low Input Landrace Cocoa or LILC), as calculated from Mahrizal et al. (2013), was \$445.57 per hectare per year for the 50 years of the two production cycles. The NPV associated with the completion of CLP training was estimated at \$846.57 or a 90% increase from the baseline. This includes \$163.73 per year in increased input costs, modeled after High Input Medium Shade Cocoa (HIMSC) in Afrari-Sefa et al. (2010). Initially, it would seem infeasible for yield to increase only 75% but the NPV to increase by 90%. This is explained by the fact that yield is increasing at a greater rate than cost, 75% compared to 54%. Thus, as long as yield increases at a rate of greater than 54%, NPV gain can be larger than yield gain. This would seemingly indicate that CLP training is an effective way of increasing producer revenue even with the associated new input costs for fertilizer, fungicide, and herbicide. If all 44,200 Ghanaian CLP participants were to experience this gain (\$401.00 per hectare), that would result in an annual total gain of \$17,724,200 in Ghana alone. For the 52% of the Ghanaian population living on \$2 or less a day (\$730.00 annually), \$401.00 equates to a 54.9% increase in income, a

considerable jump by most standards. For the poorest of the poor, the 27% of the population living on \$1.25 or less per day (\$456.25 annually), \$401.00 results in an 87.9% increase in income. Roughly 2% of the Ghanaian population are poor cocoa farmers, indicating that cocoa production could be a road out of poverty. Based off the calculations from Table 4, it is clear that CLP training is helping to raise incomes for cocoa farmers, ideally leading to improved livelihoods and overall quality of life.

Given that output results could be inflated on an interview-based survey, a sensitivity analysis was also conducted to see how various levels of yield increases affected NPV and what the minimum level of yield increase was needed to at least break even and cover the costs of the increased inputs (Table 4). Instead of using the estimated 75.24% yield increase as estimated from Table 3 for the completion of input promoter (*IP*) training, 50% and 25% yield increases were selected as reference points to calculate NPV percent gain from the baseline and to compare with the BCR associated with a 25% assumed training gain (1.087) as estimated in Afari-Sefa et al. (2010). NPV increased 46.53% and 3.06% for the 50% and 25% yield increases, respectively. In these cases, costs increases (54%) were greater than yield increases and thus the NPV increase was smaller than the yield increases. Finally, the break-even yield increase was estimated, finding the yield increase level (23.25%) in which additional revenue would equal the increased input costs, thus yielding a 0% change in NPV. Given the large difference between the estimated 75.24% *IP* yield increase and the break-even yield increase of 23.25%, these results appear to be robust in terms of increased producer profitability (Table 4). These figures also suggest farmers would need to artificially inflate their yield by 324% ( $75.24/23.25$ ) for the additional input costs to negate the NPV gains from farmer training.

### 4.3 Benefit Cost Ratio

Table 5 presents the 50-year extrapolations (two cocoa production cycles) of the annual NPV calculations found on Table 4. As such, the table illustrates (1) the total NPV for the baseline scenario (LILC) from Mahrizal et al. (2013), (2) the total NPV for completing the training program (*IP*) utilizing the 75.24% yield increase associated with the statistically significant *IP* training course found on Table 3, and (3) a sensitivity analysis to provide reference points and the break-even point. By comparing the baseline scenario NPV and the training NPV, the NPV gain (benefit) associated with training can be approximated.

When extrapolated over 50 years, the LILC, baseline scenario (no CLP training) NPV was \$22,279, whereas the 75.24% yield increase (from completing *IP*) NPV was \$42,329, a difference of \$20,050 (2010 dollars) per hectare. Therefore, the benefit associated with training represents \$20,050 per hectare. With a total training cost of \$252 (\$36 for FFS, \$16 for FBS, and \$200 for *IP*), the benefit-cost ratio (BCR) was calculated to be 79.56:1 ( $20,050/252$ )<sup>9</sup>. That is, for every \$1 invested into the CLP farmer training program, the return on investment (increased NPV per hectare for small scale cocoa producers) was roughly 80 dollars, which is a large return based on any measure, and particularly when compared to the 1.087 BCR from Afari-Sefa et al. (2010). It should be noted that this is a conservative estimate considering the calculations are on a per hectare basis. If a producer was to produce on two hectares, then the BCR would be 159.12:1 ( $20,050*2/252$ ). One hectare was the unit of measurement for the NPV/BCR model because a selection criterion for CLP is having access to at least one hectare of land to establish a new cocoa farm planted with hybrid cocoa once training is complete. The BCR ratio provides a clear illustration of the strength of human capital development in poverty alleviation, instilling

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<sup>9</sup> This assumes there are not multiple people farming the same hectare.

knowledge in the farmers that can be used well past the year of training while increasing incomes by \$79.56 per hectare for every \$1 invested in initial training.

A sensitivity analysis was also conducted at the 50% and 25% yield increase levels to provide BCR reference points. Compared to the baseline, LILC model calculated from Mahrizal et al. (2013), the 50% and 25% levels respectively resulted in NPV gains of \$10,366 and \$682 per hectare over the 50-year period. With a total training cost of \$252, the BCR was calculated to be 41.13:1 and 2.70:1. These returns are still well above the break-even ratio of 1.0 and are well below the yield increases reported by producers leading to the notion that these results are both robust and that investment in the CLP was worthwhile.

To further analyze the benefit cost ratio, a break-even yield increase was estimated that results in a BCR of 1:1. The break-even yield increase necessary for benefits to equal costs was estimated at 23.89%, which includes both the cost of training (\$252) and costs of increased input use (\$163.73 per year). Any training yield increase less than 23.89% per hectare results in a BCR less than one. Again, this would assume that a producer only produces one hectare. The BCR could be greater than one with a lesser yield gain if they produced on more than one hectare. While most cocoa producers are small scale in Ghana, they typically produce on more than one hectare.

## **5. Conclusion**

In Ghana, where approximately 52% of the population lives on USD \$2 a day or less, 27% live on \$1.25 or less per day, and 19% of rural households produce cocoa, agricultural development in the cocoa sector has the potential to increase incomes for the poorest of the poor. While billions of dollars flow into low-income countries each year to alleviate poverty, assessing the full impact of these programs can be difficult. For studies that do measure the benefits of

development programs, many lack a temporal dimension because they measure costs and benefits in a single, static year or do not account for the full benefit of human capital development. Farmer training programs can provide skill development that is utilized long after the training is complete. Given that the primary intent of the CLP is to increase cocoa yield and farmer quality of life through training in production practices, financial management, and input use, calculating the costs and benefits that extend beyond the five years of the program generates information to more efficiently invest scarce resources.

Using primary data collected in summer 2011 from the 2010-2011 growing season and a baseline model from Mahrizal et al. (2013), the goal of this study was to estimate the NPV of CLP training over a 50-year period—two cocoa production cycles. Using multiple regression analysis to determine the effect of CLP on yield and thus NPV, it was estimated that cocoa yield rose 75.25% per hectare after completing all CLP training. This resulted in an annual NPV gain of \$401.00 per hectare or a 90% increase in annual NPV compared to the baseline model. When extrapolated over 50 years to account for human capital development, training is associated with a \$20,050 per hectare total increase in NPV. With a total training cost of \$252, the BCR of the CLP was 79.56:1 meaning for every \$1 invested in the program, farmers' income increased by \$79.56 per hectare, a considerable jump by most standards.

These results should be considered a conservative estimate given the fact that the costs are fixed at \$252, but the benefits vary by farm size. That is, this study assumed that producers only produced one hectare of cocoa. If they produced on more than one hectare, the costs remain fixed at \$252 per person but the benefits increase, thus increasing the BCR. As noted previously, the average farm size was 3.2 hectares. WCF also estimates that training costs decrease over time as training networks are established. The higher costs of the trial programs allow for a more

conservative NPV estimate for training. Furthermore, it was assumed farmers were already maximizing income stability through an optimal tree replacement rate and an optimal initial year of replacement. Farmers who were not optimizing replacement would have lower yield values than the baseline scenario, and thus receive a greater NPV gain after training.

Nevertheless, there are some limitations to this study. Farmers were reported to either use specific inputs or not, but the input application rate was not known. A more accurate study would include specific rates to better compare input use and yield. Collecting this data would likely result in a higher R-squared value. Additionally, the age of the trees was not gathered because of farmers' inability to recall the ages and replacement rates of all of their plots. Future research should also incorporate a control group completely unaffiliated with the training program and that has received no prior training, even for training that could not have an effect on yield. This is significant for the self-selection issues that exist within communities that receive training and the ability for farmers to share CLP skills with other farmers in the community. These three limitations exist largely from the financial infeasibility of conducting a study in West Africa with perfect information on agricultural practices, yield, and cost.

These results can be used by development NGOs to illustrate the potential of skill attainment in alleviating poverty, particularly when encouraging prospective donors, technical partners, or governments. Moreover, by measuring costs and benefits beyond the years of the program, this study provides an established standard in estimating the net present values of other development programs, ideally providing citizens of low-income countries more opportunities to lift themselves out of poverty and contribute to the global economy.

## 6. Tables and Figures

Table 2: Descriptive statistics for regression analysis.

District	Atwima Nwabiagya	Juaboso	Sefwi Wiawso	Birim South	Overall
Total Participants <i>n</i>	16	59	32	76	183
Average Yield (kg/ha)	213.2	681.9	854.9	420.3	562.6
Farmer Field School Training ( <i>FFS</i> ) % (1=trained, 0=not trained)	50	93.2	68.8	72.4	76.5
Farmer Business School Training ( <i>FBS</i> ) % (1=trained, 0=not trained)	93.8	64.4	96.9	63.2	72.1
Input Promoter Training ( <i>IP</i> ) % (1=trained, 0=not trained)	0	32.2	6.3	0	11.5
Gender % (1=male, 0=female)	81.3	55.9	71.9	75	68.9
Average Farm Size (ha)	2.9	4.2	3.8	2.3	3.2
Farmer-Based Organization ( <i>FBO</i> ) Membership % (1=FBO membership, 0=no FBO membership)	50	59.3	28.1	32.9	42.1
Inorganic Chemical Fertilizer ( <i>Fert</i> ) % (1=used inorganic fertilizer, 0=did not)	12.5	84.7	62.5	48.7	59.6
Fungicide ( <i>Fung</i> ) % (1=used fungicide, 0=did not)	18.8	93.2	59.4	68.4	70.5
Herbicide ( <i>Herb</i> ) % (1=used herbicide, 0=did not)	6.3	22	25	44.7	30.6
Insecticide ( <i>Insect</i> ) % (1=used insecticide, 0=did not)	18.8	88.1	53.1	57.9	63.4
Using Improved Varieties ( <i>ImprVar</i> ) % (1=used improved varieties, 0=did not use)	18.8	66.1	46.9	55.3	54.1
Certified Seed Source %	18.8	30.5	12.5	36.8	29
Friend's Farm Seed Source %	68.8	40.7	37.5	23.7	35.5
Own Farm Seed Source %	12.5	27.1	50	34.2	32.8

\*Due to missing observations, *n*=138 for the regression model estimates.

Table 3: Regression Results.

Variable	Coefficient	Variable	Coefficient
Constant	4.92 (7.16)***	Insect	0.29 (1.78)*
FFS	0.57 (0.86)	Herb	-0.20 (-1.19)
FBS	0.022 (0.14)	ImprVar	0.13 (1.00)
IP	0.56 (3.38)***	FrieFarm	-0.19 (-1.53)
Gender	0.29 (2.31)**	CertSeed	-0.26 (-1.62)
FarmSize	-0.037 (-3.34)***	Atwima	-0.63 (-3.07)***
FBO	0.11 (0.74)	Juaboso	0.12 (0.60)
Fert	0.43 (2.36)**	Sefwi	0.45 (2.88)**
Fung	-0.094 (-0.53)		

Note:  $n=138$  and  $R^2=0.36$ .

\*\*\* Denotes statistically significant at the 1% level.

\*\* Denotes statistically significant at the 5% level.

\* Denotes statistically significant at the 10% level.

Parentheses denote t-ratio.



Table 4: Summary of net present value (NPV) and percentage change in NPV over two production cycles (50 years) for the LILC production system with estimated yield increases from the Cocoa Livelihoods Program (CLP) input training.

Yield Increase	Net Present Value (NPV)* <sup>†</sup>	NPV Change (\$ per Ha)	Percent Change from Baseline
Baseline**	\$445.57	-	-
75.24%***	\$846.57 <sup>††</sup>	\$401.00	90.00
50%	\$652.89	\$207.32	46.53
25%	\$459.20	\$13.63	3.06
23.25%	\$445.57	\$0.00	0

\* Denotes net present value in 2010 USD per hectare per year.

<sup>†</sup> The discount rate is based on Ghanaian Treasury bill rates for a six month period in 2010, is 10.67%. (Bank of Ghana, 2011a).

\*\* Equivalent to the Baseline Value in Mahrizal et al. (2013), which is a producer with no CLP training

\*\*\* Estimate obtained from Table 3.

<sup>††</sup> Includes the increased costs used on inputs assumed to be used after input training. Annual total cost increase from use of inputs is 54% or \$163.73 per year.

Table 5: Sensitivity Analysis of the Benefit Cost Ratio for the Cocoa Livelihoods Program (CLP) Input Training Course in Ghana.

Yield Increase	Net Present Value (NPV)* <sup>†</sup>	NPV Change From Baseline	Total Training Costs**	Benefit Cost Ratio
Baseline***	\$22,279	-	-	-
75.24%****	\$42,329 <sup>††</sup>	\$20,050	\$252	79.56
50%	\$32,645	\$10,366	\$252	41.13
25%	\$22,960	\$682	\$252	2.70
23.89%	\$22,531	\$252	\$252	1.00

\* Denotes net present value in 2010 USD for one hectare over two cocoa production cycles (50 years).

<sup>†</sup> The discount rate is based on Ghanaian Treasury bill rates for a six month period, or 10.67% in 2010 (Bank of Ghana 2011a).

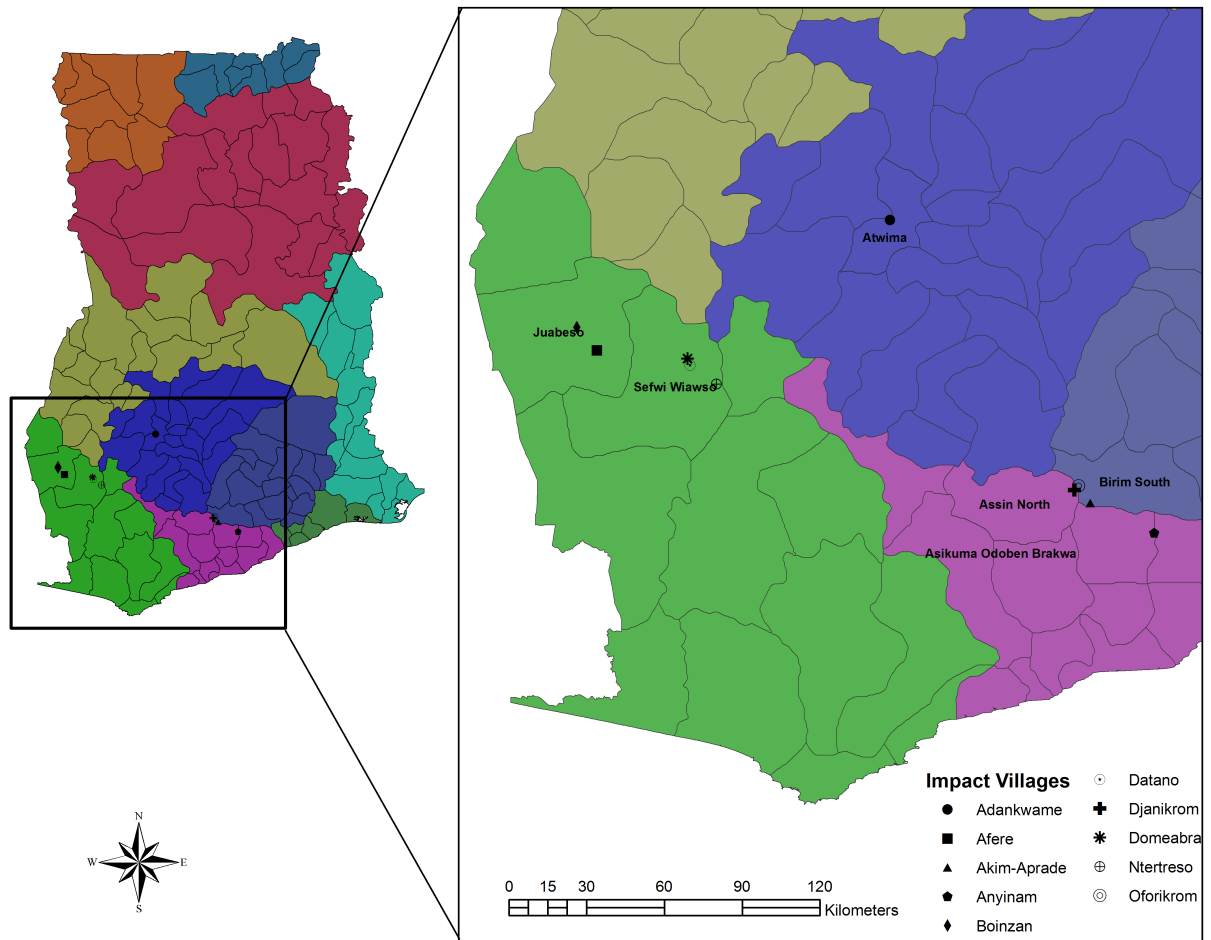
\*\*Costs are not discounted because they are all incurred in year one of the program.

\*\*\* Equivalent to the Baseline Value in Mahrizal et al. (2013), which is a producer with no CLP training.

\*\*\*\* Estimate value obtained from Table 3.

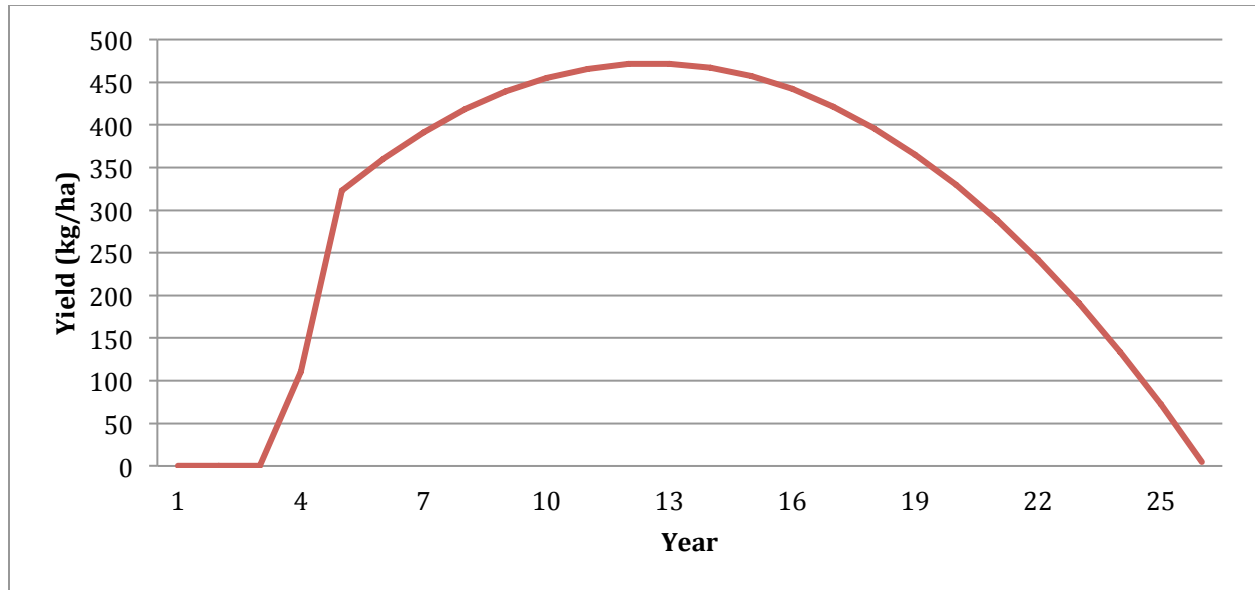
<sup>††</sup> Includes the increased costs used on inputs assumed to be used after input training. Annual total cost increase from use of inputs is 54% or \$163.73 per year.

Fig. 1: Location of Cocoa Livelihood Program (CLP) Villages used in the Study.



Map Source: ArcGIS (2013).

Fig. 2: Cocoa yield in a Low Input Land Race Cocoa (LILC) Production System in Ghana



Source: Gockowski et al. (2009) and Afari-Sefa et al. (2010).

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